Treatment Wetland Applications

Chapter Highlights

- Societies generate concentrated wastewater that must be treated before it is released back into the environment.
- Constructed wetlands provide wastewater treatment with minimal technical, energy, and chemical inputs.
- Point source and non point source wastewater can be treated in a constructed wetland system.

Municipal Wastewater Treatment

Civilizations have dealt with wastewater for thousands of years. Normal uses of water for hygiene, consumption, and manufacturing generate a pollutant load on the resulting wastewater. In order to prevent contamination of drinking water supplies and the surrounding environment, wastewater must be isolated until pollutant removal is accomplished.

Wastewater treatment has developed in the last century from outhouses and septic systems to piped collection systems that deliver wastewater to centralized treatment facilities. As populations have become denser, wastewater treatment has become a vital, and often expensive, part of a community life style. These centralized collection facilities use a myriad of treatment processes before the reclaimed water is released back into the natural system.

Treatment facilities are designed to fit into the communities that they service. For instance, dense metropolitan areas, in which real estate is at a premium, require facilities that can treat large amounts of wastewater in compact areas. In addition, wastewater from metropolitan areas typically originates from both industrial and domestic sources and may require advanced methods to meet treatment goals. However, in rural areas, land is more available and wastewater is from domestic sources, with minimal industrial inputs. Smaller communities are often constrained by their limited capital and technical resources. In these areas, land intensive treatment options are often desirable. Constructed wetlands, as a component of a treatment process, provide a low energy, low-tech method of removing pollutants.

Constructed wetlands can be used as a treatment component in municipal wastewater treatment facilities. Generally, wetlands are used as a 'finishing' component in the treatment process. Some of the benefits of constructed treatment wetlands are discussed in this chapter.

Minimal Energy Consumption

Elevation differences in the wetland can be provided to allow wastewater to flow by gravity through the wetland system. Energy consumption in the treatment system is generally limited to the amount of energy consumed by the primary treatment method.

Fecal coliforms are bacteria that live in the intestinal tract of mammals. The presence of these bacteria in wastewater is an indicator of mammalian waste products.

Chlorine is a low cost chemical that has been proven to provide reliable disinfection. It destroys almost all water borne pathogens, including fecal coliforms.

Minimal Use of Chemicals

The wastewater treatment reactions in a wetland depend on physical, chemical, and microbial processes that occur naturally in the system. Some use of chemicals may be necessary in order to reduce **fecal coliform** levels in the effluent prior to the release of the treated water into a receiving water body. **Chlorine** is a popular form of disinfection used in both natural and conventional treatment systems. The use of **UV or ultraviolet light** in a wetland system provides reliable disinfection without the use of chemicals. In some wetland systems long detention times and exposure to sunlight provide sufficient disinfection, and as a result, additional means of disinfection are unnecessary.

Low Tech

Wetlands are designed to have simple hydraulic and mechanical systems. Since the treatment processes are naturally carried out, operators do not have to monitor the treatment process. The primary tasks of the operator are to keep the hydraulic system running, manage wildlife and the occasional harvesting or burning of excess vegetation.

Ancillary Benefits

Wetlands can be an aesthetic addition to a community. As such they provide open space and associated recreational activities (i.e. hiking, bird watching, etc.). They can also provide valuable habitat for birds, small mammals, and other creatures.

On-site Residential Treatment

Approximately 25 percent of the U.S. population lives in rural areas and relies on decentralized, or on-site, wastewater treatment systems. Isolated communities in the Rocky Mountains face the challenges of wastewater treatment with the added complications of cold weather and rocky soils that are not well suited for traditional **leach fields**. On-site residential treatment is necessary in many remote areas that are unable to connect to centralized sewer systems. In many western slope communities, laying the network of pipelines necessary for a centralized wastewater treatment system is not feasible because of mountainous topography and the need to blast through rock.

Benefits of Constructed Treatment Wetlands

- Low energy consumption
- Minimal chemical usage
- Simple hydraulic systems – easy to operate
- Aesthetically pleasing
- Educational value
- Valuable habitat

UV or ultraviolet light is a type of radiation that acts as a physical (not chemical) disinfectant. UV radiation penetrates the cell walls of bacteria and other water pathogens, and impairs their ability to replicate and in some cases causes the cell to die. This disinfection method is only effective if the UV radiation can reach the wastewater. Typically, UV lights are placed on a rack and then submersed in wastewater. As the wastewater flows through the UV lights, it is disinfected.

A **leach field** is a subsurface system used for final treatment and disposal of septic effluent. Leach fields are composed of a series of narrow, shallow trenches in which perforated pipes are installed and surrounded by gravel. The trenches serve several purposes that include:

- Maintaining the leach field's structure
- Providing partial treatment of wastewater
- Distributing wastewater beneath the soil surface

Another problem associated with lengthy collection systems is the potential for contamination of the watershed due to leaky pipes and fittings.

Acid Mine Drainage Treatment Wetlands

Wetlands have been used to treat runoff from hard rock and coal mines. This runoff is known as Acid Mine Drainage (AMD). The characteristics of AMD depend on the mine type. Generally these sites have high iron, sulfur, and heavy metal contents. When areas are mined, rock that was buried deep in the ground is broken apart and exposed to oxygen. In rock types that are mined for metals or coal, high amounts of sulfur and iron are generally present. When the iron and sulfur are exposed to oxygen, they become oxidized and sulfuric acid is formed. This acid is dangerous because of its low **pH**. Water with a low pH has a greater ability to dissolve heavy metals. Metals that were at one time chemically bonded within the rock change **valence** states and are dissolved by water flowing through the mine. This leads to higher metal concentrations in runoff. The presence of these metals can be very dangerous to humans, wildlife, livestock, and vegetation.

Oxidation-reduction reactions or redox reactions refer to two reactions. The first part of the reaction, called oxidation refers to the loss of an electron by one of the reactants. The second part, reduction, refers to the gain of an electron by one of the reactants. Oxidation and reduction always occur together. The substance that is oxidized is the reducing agent, while the substance that is reduced is the oxidizing agent.

Chemical reactions occur in wetlands that affect metals in a variety of ways. In a natural wetland, **oxidation-reduction (redox)** reactions are important to **metal speciation**. Factors that influence these reactions are saturation, water flow, soil chemistry, and vegetation. Oxidizing conditions may exist near a wetland surface. In this region, metals may be oxidized, forming precipitates, or may **adsorb** on to soil particles. Oxidation reactions occur near the wetland surface and where **hydrophytic** plant's roots affect the soil. Below this, wetlands can isolate metals from oxidizing conditions, keeping metals in a reduced state. Soils are reduced where conditions are permanently saturated and where oxygen is used up at a greater rate than it is replaced. It has been shown that oxygen flows through aqueous solutions 10,000 times more slowly than through porous soil media. Therefore, when soils are saturated, oxygen diffusion is severely restricted and metals are not dissolved in the water.

Adsorption is a process where molecules of gas or liquid "cling" to the surface of a solid. There is no physical or chemical change to either substance.

Absorption is a process where one substance, usually a gas or liquid, is drawn into and fills another. This is accompanied by a physical and/or chemical change of the substance.

An important aspect of oxidation-reduction in dynamic systems, such as mine acids or other

pH is a measure of the acidity of a substance. The pH scale ranges from 1 to 14. A pH of 1 means a substance is very acidic, while a pH of 14 means it is alkaline (basic). Water has a pH of approximately 7 and is considered neutral.

Benefits of Acid Mine Drainage Treatment Wetlands

- Isolates metals
- Neutralizes pH of runoff water before entering

A valence reflects the combining power of an atom. This is measured by the number of hydrogen atoms with which it can displace or combine.

Metal speciation refers to the variety of metals of one kind that can exist in different valence states.

A hydrophytic plant can also be called a "water-loving" plant. These types of plants have the ability to grow in soil that is saturated by water for extended periods.

sources of AMD is pulses in water levels and flows associated with spring runoff or other flood events. The apparent effect of these events is to damage structures in created wetlands.

There are several studies in Colorado that have examined the treatment of AMD by passive systems, such as bioreactors: Silverton, the Eagle Mine Superfund Site in Minturn (Colorado School of Mines, 1992), and Marshall, Colorado (de Forest, 1985). Few studies have been conducted in natural wetlands in Colorado, and only one study was found that was conducted in a constructed wetland (Idaho Springs). One study on a natural wetland near the Pennsylvania Mine in Peru Creek drainage, near Montezuma, Colorado, involved routing of AMD through an existing wetland (Huskins, 1987). The results of this study showed that the wetland removed iron from the AMD, but because of the low pH, ranging from 3.5 to 4.0 in different depths in the wetland, the ability of iron to co-precipitate other metals was limited. A second study in St. Kevin's Gulch, near Leadville, showed that AMD passing through a wetland showed that iron was removed from the water passing through the wetland, but that zinc was not (Walton-Day, 1996).

Stormwater Wetlands

Constructed wetlands are commonly used to detain and treat stormwater runoff. Stormwater runoff, also known as **non-point source pollution**, may contain a variety of contaminants, chemicals, and nutrients. Stormwater treatment wetlands may treat runoff from residential areas, roads, commercial areas, and parking lots. Typical constituents of stormwater runoff may include BOD, suspended solids, nitrogen, nitrate, and nitrite, phosphorous, copper, lead, zinc, chromium, cadmium, iron, mercury, nickel, phenols, cyanides, soaps, pesticides, herbicides, fertilizers and oil and grease. Treatment wetlands must be designed not only to process all of these, but also to serve as floodwater retention facilities.

In the Denver Metropolitan area, the Urban Drainage and Flood Control District (UDFCD) and others recommend a combination of **sediment detention basins** and wetlands as an efficient means to treat stormwater. In this scenario, sediment detention areas (such as those discussed in Chapter 4) are placed up-gradient of the treatment wetlands, and can either be immediately adjacent to or well away from the wetlands. These sediment basins decrease the sediment load in the wetlands so that the treatment wetlands function more effectively to remove nutrients and chemicals.

Natural wetlands can be used as stormwater treatment areas, but it is important to ensure that the implementation of this form of stormwater treatment complies with all federal and state laws. The U.S. Army Corps of Engineers and the EPA have expressed concerns about using natural wetlands for stormwater treatment.

Non-point source pollution is typically from a variety of sources, while **point source pollution** is from a singular source, such as a pipe or body of water.

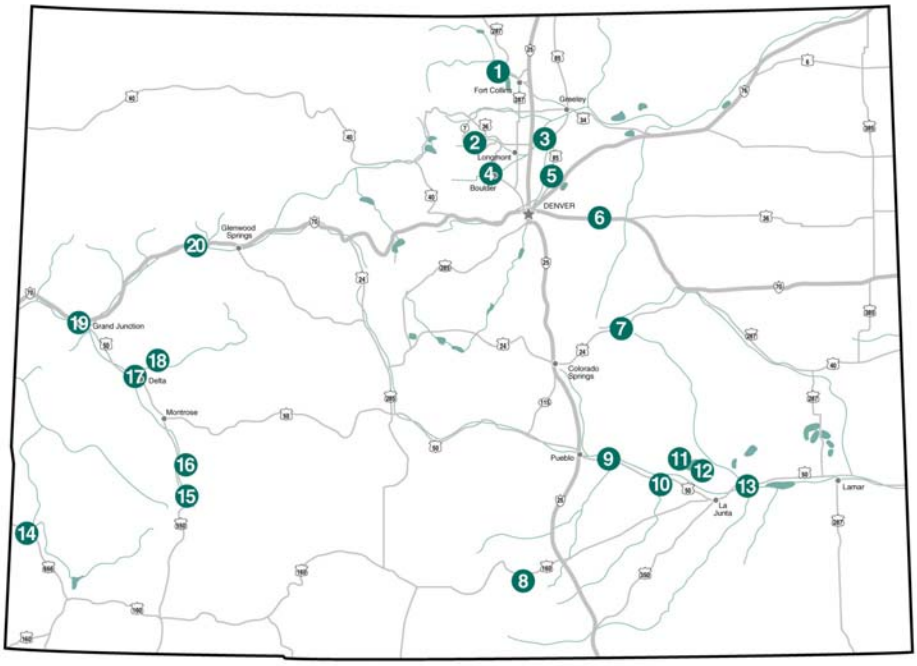
Sediment detention basins are usually large, shallow earthen basins used to separate out solids from wastewater.

Compliance with Regulations

The Colorado Department of Health & Public Environment (CDPHE) is the governing agency for water quality requirements for wastewater treatment facilities that discharge into a receiving body of water. All wastewater treatment facilities must be in compliance with their regulations or a "notice of non-compliance" is issued by the CDPHE. If a facility is out of compliance for a longer period of time, the CDPHE will issue a "cease and desist" order. At this point, the facility owner may lose their discharge permit and legal action can be taken against them.

What Is Included In This Study

This study focused on constructed wetlands that treat municipal wastewater. Constructed treatment wetlands were identified by Task Force members and consultants through personal knowledge, researching contacts and a literature review. Municipal treatment wetlands have the most data, since discharge permits require the submission of monthly water quality tests. The project team pulled discharge permits from the Colorado Department of Public Health



Colorado Map – Sites Inventoried

and Environment (CDPHE) files in order to get background information and water quality data for each site.

A representative sample of stormwater and other miscellaneous constructed wetlands were also visited. However, since water quality data was not available for these sites, an extensive analysis was not undertaken.

Sites Inventoried

The map to the left shows locations of constructed treatment wetlands that were inventoried. Further details on each site can be found in Chapter 6.

1. **Rocky Mountain Shambhala Center**
2. **Highlands Presbyterian Camp**
3. **Platteville**
4. **Valmont Power Plant**
5. **Brighton**
6. **Bennett**
7. **Calhan**
8. **La Veta**
9. **Avondale**
10. **Manzanola**
11. **Crowley County Correctional Facility**
12. **Crowley**
13. **Las Animas**
14. **Dove Creek**
15. **Ouray**
16. **Ridgeway State Park**
17. **Delta**
18. **Horizon Nursing Home**
19. **Island Acres Silt Park**
20. **Silt**